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Federal Communications Commission
Office of Secretary

DELIVERY BY HAND

November 25, 1996

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, N.W.
Washington, D.C. 20554

Re: Notice of ex parte presentation in RM-8811, ET Docket No. 95-183, RM-8553, PP Docket No. 93-253, ET Docket No. 94-124, RM-8308

Dear Mr. Caton:

Motorola Satellite Systems, Inc. ("Motorola"), through its attorneys, and pursuant to Section 1.1206 of the Commission's rules, hereby reports that an oral ex parte presentation was made on this date by representatives of Motorola to the International Bureau. Those persons in attendance were Donald Gips, Ruth Milkman, Cecily Holiday, Steve Sharkey, and Damon Ladson. During this presentation the attached documents were distributed and discussed along with the positions of Motorola as set forth in its comments in the above-referenced proceedings.

An original and six copies of this letter are being submitted for inclusion in the above-referenced dockets. Copies of this notice are also being sent to those Commission personnel in attendance at the presentation.

Respectfully submitted,

Philip L. Malet

Counsel for Motorola Satellite Systems, Inc.

cc: Donald Gips
Ruth Milkman
Cecily Holiday
Steve Sharkey
Damon Ladson

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ANALYSIS OF SHARING BETWEEN FS AND NONGSO FSS IN THE BAND 37.5 TO 40.5 GHZ - NOV. 21, 1996

1.Introduction

Motorola has performed a new sharing analysis between the down link of a NonGSO FSS system like M-Star and high density FS in the bands from 37.5 to 40.5 GHz. Based on this analysis it now believes that full band sharing between these networks is practical with rules that would allow both to meet their business plans. This can be achieved with the simple constraint on FS transmitters of a maximum EIRP of:

-22 dBW/MHz in clear air with higher powers allowed as necessay to overcome infrequent increases in atmospheric losses

as opposed to the earlier recommendation in MW/40 of -28.4 dBW/Hz. This increase in permissible EIRP is a consequence of the review of the information contained in:

1. Ex Parte by ART to the FCC dated Nov. 6, 1996
2. Contribution to Ad Hoc MW/48 drafting group dated Nov 13, 1996

Using the analysis methods described in Motorolas original sharing analysis, this increase in EIRP spectral power density from FS transmitters is achieved by:

1. Lower sidelobe satellite earth terminal antennas
2. Increase in permissible Io/No into the satellite receiver for short term interference
3. Use of FS equipment parameters as described in the data sheets
4. Increase in the FS static link margin from 6 to 7 dB at maximum range
5. Consideration of possible in line interference from the satellite to FS receivers

Clarification of the quick reaction coordination/notification procedures is provided. These procedures are to be used to assist M-Star in employing the necessary interference mitigation techniques whenever FS transmitters are to be located within 1 km of an earth terminal.

This paper also contains a review of the practicality and advantages to FS in the use of adaptive power control to achieve high availability in the presence of rain induced fades. This review relies heavily on TIA/EIA Telecommunications Bulletin #TSB10-F "Interference Criteria for Microwave Systems. The bulletin demonstrates that spectrum reuse efficiency between FS is significantly increased with the use of ATPC which is a most important criteria for the high density deployment planned by the FS in this band.

2. Sharing between FS and NonGSO FSS Down Link at low elevation angles

The M-Star satellite network is designed to operate with a minimum elevation angle of 22° for its service links. This restriction is necessary in order to achieve high availability without excessive link margin in these frequency bands. With the latest FS equipment characteristics and the new EIRP limitation, the FS static link margin can be calculated at maximum range as follows.

Maximum Range - FS to FS link

Tmasmitter Power density	-126	dBW/Hz
FS Antenna Gain	44	dBi
EIRP density	-82	dBW/Hz **(-22 dBW/MHz)**
Free Space Loss (7.3 km)	-141.8	dB
Atmospheric Loss	-1.0	dB
FS Antenna Gain	44	dBi
Received Power Co	-180.8	dBW/Hz
Receiver Noise Temp 1830°	32.6	dB-K
Receiver Noise No	-196	dBW/Hz
Carrier/Noise Co/No	15.2	dB
Required Co/No	8	dB
Margin	7.2	dB

As can be see there is a static 7.2 dB margin to accomodate minor pertubations in the link. Consider now a FS station located 1 km from the FSS earth station and pointed directly at its location on a level with the earth station. While the FSS antenna is continually tracking the satellite there can be times when the antenna is at its minimum elevation of 22° and on a radial towards the FS site. Thetransient interference link for this worst case can be evaluated as follows.

Minimum Range - FS to FSS link

Tmasmitter Power density	-126	dBW/Hz
FS Antenna Gain	44	dBi
EIRP density	-82	dBW/Hz **(-22 dBW/MHz)**
Free Space Loss (1 km)	-124.5	dB
Atmospheric Loss	-0.1	dB
FSS Antenna Gain (22°)	-4.5	dBi (29-25logθ)
Received Power Io	-211.1	dBW/Hz
Receiver Noise Temp 503°K	27.0	dB-K
Receiver Noise No	-201.6	dBW/Hz
Interference/Noise Io/No	-10.5	dB

This peak transient Io/No of -10.5 dB is considered acceptable by Motorola. A single FS transmitter sited in this unfavorable location would not actually reach this level more than .01% of a year so there would be no degradation M-Star perfomance objectives. However, if many more than 1 station should contribute this level of interference into a particular earth station, the earth station operator would have to consider the need for mitigation such as site shielding. Similarly, if a FS station should be located within the 1 km distance and pointed directly at the earth station, shielding may be required. It should be noted that a spacing of 250 meters would only increase the transient Io/No to -4.5 dB which by itself may still be acceptable.

3. Sharing between FS and NonGSO FSS at High Elevation Angles

Consideration must be given to the occassional main beam to main beam coupling that could occur between the satellite down link and a FS receiver directed upwards at an elevation equal to or greater than 22 degrees. First consider the FS link margins in such a case as shown below with an assumed elevation angle of 20 degrees to a building or mountain that is 1100 feet higher which sets the slant range to about 1 km. This is the lowest elevation angle that near main beam to main beam coupling can occur.

High Elevation Angle - FS to FS link margin

Trnasmitter Power density	-126	dBW/Hz
FS Antenna Gain	44	dBi
EIRP density	-82	dBW/Hz (-22 dBW/MHz)
Free Space Loss (1.0 km)	-124.5	dB
Atmospheric Loss	-0.1	dB
FS Antenna Gain	44	dBi
Received Power Co	-162.6	dBW/Hz
Receiver Noise Temp 1830°	32.6	dB-K
Receiver Noise No	-196	dBW/Hz
Carrier/Noise Co/No	33.4	dB
Required Co/No	8	dB
Margin	25.4	dB

The down link transient interference for the case when the satellite down link beam intercepts the main beam of the FS receiver can now be calculated as follows.

Maximum Transient Interference - FSS to FS receiver

Trnasmitter Power density	-88.6	dBW/Hz
Satellite Antenna Gain	40.6	dBi
EIRP density	-48	dBW/Hz
Free Space Loss (2586 km)	-192.7	dB
Atmospheric Loss	-1.8	dB
FS Antenna Gain	44	dBi
Received Power Io	-198.5	dBW/Hz
Receiver Noise Temp 1830°	32.6	dB-K
Receiver Noise No	-196	dBW/Hz
Transient Io/No	-2.5	dB
Carrier to Interference Co/Io	35.9	dB
Carrier to Total Noise Co/(No+Io)	31.5	dB

As can be seen, with a nominal EIRP spectral density of -22 dBW/Mhz, the short range high elevation angle FS links are quite robust to the occassional main beam to main beam interference from the satellite down link. The carrier to noise only temporarily reduced from 33.4 dB to 31.5 dB. Simulations for similar in line statistical events from a low earth orbiting satellite suggest that the frequency with which these transient peak noise events would occur over a years span is about .0001% from a constellation. Clearly this transient interference would have no performance impact on a FS link. At higher elevation angles the interference level would be some what higher but the probability that the high structure would block the satellite interference to the FS receiver is greatly increased as well.

There is the possibility of higher interference into the satellite receiver from a high altitude FS at 1 km distance as it could be nearer to main beam to main beam event. However, a 1° spot beam has a 3 dB radius of only 34 meters at 1 km distance and therefore, the satellite receiver would have to be essentially colocated with the FS receiver. That close to a high structure would present a problem for the satellite tracking antenna in terms of potential blockage to the satellite. It possible the satellite would have to employ alternate satellite selection for some passes to avoid blockage which is also a worst case mitigation scenario for interference from a FS station.

4.0 The Use of Adaptive Transmitter Power Control (ATPC)

The FS desires to achieve extremely high availability objectives for these 40/50 GHz links. The FS link margins used in the preceding analyses to insure sharing with FSS, will not meet those objectives due to the high propagation losses occasionally induced by rain. Clearly the use of ATPC will be needed to insure meeting those objectives. TIA/EIA Telecommunications Bulletin #TSB10-F "Interference Criteria for Microwave Systems" provides an excellent source of information on the benefits of ATPC for frequency sharing among FS. These benefits are clearly most appropriate for the 40/50 GHz FS networks as currently envisioned and are described in the Annex to this document.

The 40/50 GHz FS networks contemplate extremely high density networks employing higher order signaling techniques such as QAM which create higher out of band emissions , are more sensitive to self interference, and require higher linearity in the transmitters and receivers to avoid intersymbol interference. The use of ATPC would improve FS spectrum use efficiency for these type of FS networks along with the most obvious problem of in-line co-frequency self interference.

If all links carry high fade margins and since rain fading is spatially restricted, then there is the high probability a receiver's main link would be faded and all other links would still continue to put high signals into its side lobes. On the other hand, when a ATPC link powers up to overcome rain attenuation, the increased power is attenuated to potentially victim receivers as well as the desired link.

In light of these benefits as outlined in TSB10-F, the comments made in MW/48 page 5 are particularly convoluted. The first point of large fixed link margins will make FS more insensitive to FSS interference is generally true but that is a crude self defeating solution. The analysis in Sections 2 and 3 of this paper were made assuming a minimum static margin of 7 dB and as can be seen there is no significant problem in sharing with the FSS down link under these conditions. There is the assertion that if "10-15 dB of ATPC were applied in a shared environment, a separation distance of over the horizon would be necessary." The logic for this huge spatial separation is more consistent with the FS desire for 50 dB <u>constant</u> fade margins not for the use of ATPC.

The last sentence "Thus, the use of ATPC for the FS side lobe coupling cases causing interference to M-Star down link will not be sufficiently effective in mitigating.." is clearly not consistent with all analysis. The FSS stations will operate to high elevation angles and it takes a close FS main beam intercept before a significant transient interference level would be noted. Since the FSS antenna is continually scanning the statistical probability a FS station would be powered up, close but a close side lobe not attenuated in the direction of the earth station , when the FSS antenna is at maximum gain in the FS station direction is insignificant.

Note 3 on page 5 makes the assertion that "manufacturers indicate that a maximum of 10-15 dB of automatic power control is the uppermost limit on todays FS equipment" Surely, that is a customer demand limit not a technological limit. Most FS to date has been deployed at frequencies less than 20 GHz were rain fading is not a factor. In addition little higher order QAM signaling systems have been deployed. Above 15 GHz there is little multipath fading to consider and therefore these links are quite stable. In the 15-20 GHz band they carry only about <20 dB static fade margin depending on the climatic zone. The Iridium™ feeder links employ adaptive power control on the up and down links in the 20/30 GHz band with a power control range of >35 dB at 30 GHz for a digital link in addition to FEC for improved fade compensation.

5.0 Quick Reaction Identification and Notification

Since both the FS and M-Star each plan a high density co-frequency co-located deployment of radio stations it is highly desireable to establish sharing rules that negate the need for "coordination" of radios in the classic sense. Motorola's proposed limitation of a nominal FS EIRP spectral density to **-22 dBW/MHz** accomplishs this objective. The burden of mitigating any harmful interference caused to a FSS receiving from a FS station is assumed to fall totally on the FSS operator.

Therefore, it is only necessary for the FS and FSS operators to maintain a data base of the locations and characteristics of all their radios within a service area. This data base should be mutually accessable by an informaton network to enable the FSS operator to rapidly determine whether mitigation is required. The FS operator could use the data base to notify the FSS operator of a new installation planned within 1 km of an existing earth station.

6.0 Summary

With one EIRP density limitation of **-22 dBW/MHz** for FS stations in the band 37.5 GHz to 40.5 GHz the public would have access to two way wide band data transfer via two different technologies. History has shown the competing technologies for the same customer create a low cost choice of options for the consumer and often both technologies will be quite successfull.

THE ADVANTAGES OF AUTOMATIC POWER CONTROL IN THE SHARING BETWEEN FIXED SERVICE AND THE FIXED SATELLITE SERVICE IN THE 38.6 - 40.0 GHZ BAND

1. INTRODUCTION

The M Star system has been designed to share with both Fixed Service and other Fixed Satellite Service systems. Under reasonable sharing rules, the M Star and the Fixed Service can both share this scarce spectrum resource.

The M Star system can share with Fixed Service if the terminals are coordinated. This is a common approach for sharing between FSS and FS systems. Motorola has proposed rules that would allow sharing without coordination. If a manufacturer would meet the rules, the equipment could be installed without coordination. Those who do not meet the rules would be required to coordinate. The choice is theirs.

The sharing rules are such that the existing licenses could meet the rules if they utilized Automatic Transmitter Power Control. The advantages of Automatic Power Control have been stated in the TIA/EIA Telecommunications System Bulletin TSB10F "Interference Criteria for Microwave Systems" which has been included as Appendix A of this document.

In Section 4.3.1 on Page 4-10 of this document it states:

> *"Automatic (or Adaptive) Transmit Power Control (ATPC) is a desirable feature of a digital microwave link that automatically adjusts transmitter output power based on path fading detected at the far-end receiver(s). ATPC allows the transmitter to operate at less than maximum power for most of the time. when fading conditions occur, transmit power will be increased as needed. ATPC is useful for extending the life of transmitter components, reducing power consumption, simplifying frequency coordination in congested areas, allowing additional up-fade protection, and (in some radios) increasing the maximum power output (improves system gain).*

2. Fixed Service Goals in the 38.6 - 40.0 Ghz Bands

Among the goals stated by the Fixed Service advocates in the 38 Ghz band are the following:

- Cost effective use of spectrum to serve large markets
- High frequency reuse
- High system reliability

It will be shown in the following paragraphs that ATPC will help the Fixed Service meet their goals.

3. Automatic Transmit Power Control in Digital Links

As stated in Section 1, TSB10-F states that; "Automatic (or Adaptive) Transmit Power Control (ATPC) is a desirable feature of a digital microwave radio link that automatically adjusts transmitter output power based on path fading detected at the radio receiver".

3.1 Link Availability will be Increased with ATPC

The link availability goal of the Fixed Service links is 99.999%. This corresponds to only 5.3 minutes per year. Obviously, an equipment failure would immediately cause this availability goal to not be achieved.

ATPC would reduce the transmit power therefore reducing the stress on a critical part in the transmitter. At these frequencies, solid state power amplifiers and low noise receivers must be implemented with expensive Gallium Arsenide MMIC technology. Reducing the temperature/time profile for these devices dramatically increases their MTBF. Therefore ATPC will enhance the system reliability. Enhancing system reliability will improve the link availability.

It well could be that, in the millimeter band for number of years, the availability of the links could be limited by equipment reliability rather than weather outages.

3.2 Total Life Cycle Cost will be Reduced with ATPC

As stated above, solid state power amplifiers must be implemented with expensive Gallium Arsenide MMIC technology. Reducing the temperature/time profile will increase the MTBF and therefore reduce the maintenance cost of an equipment failure.

The receiver design is also simplified as the dynamic signal range at millimeter frequencies would be reduced by up to 30 dB.

Although incorporating ATPC will increase the hardware cost, the reduced signal dynamic range of the receiver will reduce the hardware cost. It is estimated that the net increase in the hardware and installation cost will be less than 2%.

Considering the reduced maintenance cost due to the higher equipment reliability, the total life cycle cost will likely be reduced.

3.3 Coordination will be simplified by the use of ATPC

Use of ATPC will ease the coordination problem. Interference is caused by in-band signals and by out-of-band emissions into the adjacent band.

If the Fixed Service links do not use ATPC, the transmitters will have to be sized to operate with link margins in excess of 50 dB. These excessive transmitter powers will cause a severe potential for interference and therefore coordination problems. The use of ATPC significantly reduces the range over which an in-band signal will interfere with another Fixed Service receiver.

An even more significant effect of ATPC is on out-of-band spurious into the adjacent bands. Out-of-band spurious from ATPC transmitters are reduced as the components

APPENDIX B

A Design Approach for Implementing Automatic Transmitter Power Control in 38.6-40.0 GHz Fixed Service Equipment

1. Introduction

The following describes an approach for low cost implementation of ATPC in millimeter wave Fixed Service equipment. The approach is very simple and can be implemented at minimum cost.

2. Problem Statement:

Provide 50 dB of transmit signal level control to maintain link quality in the presence of rain fades while minimizing interference with other services in the same frequency band. Typical transmitter output into the antenna would be in the range of +17 dBm to -33 dBm. Typical modulation types are FSK, OQPSK, and QAM.

3. Implementation cost:

3.1 Link Quality Estimate and control loop.

This function is implemented with negligible cost in existing systems by use of software to compare the estimated symbol values to the actual values after forward error correction is performed. Alternatively, the quality estimate can be done by examining the variance of the symbols before decoding. The algorithm computes a link quality estimate and sends a message to the transmitter to adjust it's power level up or down as required to maintain link quality at a predetermined value.

3.2 Transmitter RF power control.

In the case of non-constant amplitude modulation, the RF power control should be implemented in a way that does not change the transmit amplifier linearity since that would degrade the spectral containment of the emission. Power adjustment by the simple expedient of bias variation on the transmit amplifier is likely to introduce nonlinearity and distortion. An attenuator can be employed either at the input or the output of the amplifier without changing linearity.

At the input, a PIN diode attenuator with 3 to 4 sections (diodes) can achieve 50 dB range at low cost. In this case the noise floor of the amplifier must not degrade signal quality when the signal is attenuated by 50 dB. A typical amplifier such as the Litton LMA 415 with 18 dB gain and a noise figure of 9dB results in a very acceptable C/N of 36 dB in a 50 MHz bandwidth.

A PIN diode attenuator at the output requires the transmitter amplifier to deliver about 2 dB more output power to overcome the minimum loss of the attenuator. This approach is less desirable since it may cause distortion by driving the amplifier into its compression region unless the amplifier is upgraded.

The cost of the PIN attenuator and its interface to the data link is less than 2% of the total material cost of the simplest Fixed Site transceiver.

4. Motorola Experience with Automatic Power Control in Millimeter Wave Terminals

Motorola has incorporated ATPC in its terminals on the Iridium Program which operate at 20 and 30 Ghz. It has also manufactured a point-to-point terminal for the U.S. Government which operated at 55 Ghz and incorporated a form of ATPC.

There is no question that a competent manufacturer can sucessfully incorporate ATPC into millimeter wave Fixed Service equipment at a minimum cost.

TSB10-F

TIA/EIA TELECOMMUNICATIONS SYSTEMS BULLETIN

Interference Criteria for Microwave Systems

TSB10-F

(Revision of TSB10-E)

JUNE 1994

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consider the overall system noise objectives in parallel with the system reliability (outage) objectives. Most analog links require significant carrier level increases above threshold sensitivity just to achieve acceptable baseband signal-to-noise (*e.g.* >35 dB increase for 70 dB S/N in the worst message channel in an FM-FDM link).

4.3 Automatic Transmit Power Control in Digital Links

4.3.1 Introduction:

Automatic (or Adaptive) Transmit Power Control (ATPC) is a desirable feature of a digital microwave radio link that automatically adjusts transmitter output power based on path fading detected at the far-end receiver(s). ATPC allows the transmitter to operate at less than maximum power for most of the time. When fading conditions occur, transmit power will be increased as needed. ATPC is useful for extending the life of transmitter components, reducing power consumption, simplifying frequency coordination in congested areas, allowing additional up-fade protection, and (in some radios) increasing the maximum power output (improves system gain).

If the maximum transmit power in a ATPC link is needed for only a short period of time, a transmit power less than maximum may (if certain restrictions are met) be used when interference calculations are made into other systems. Many years of fading statistics have verified that fading on different physical paths is non-correlated, *i.e:* the likelihood of two paths in a given area being in a deep fade and thus sensitive to interference simultaneously is very small. Further, to allow for inevitable deep fading, microwave paths are designed with unfaded carrier-to-noise (C/N) and carrier-to-interference (C/I) ratios much greater than those required for high quality path performance. Since fading is non-correlated among paths, a short-term power increase by a path experiencing a deep fade will not reduce the C/I on other paths to an objectionable level. On a properly designed path, and one not affected by rain outage, ATPC-equipped transmitters will be at maximum power for a short period of time. However, because the maximum power is available when deep fades occur, CFM, threshold C/N, and C/I calculations into an ATPC link may assume the "Maximum Transmit Power" receive carrier level

ATPC has been successfully implemented in FCC Part 21 common carrier bands for several years, and, under FCC *ET Docket 92-9*, is now permitted under Part 94. Currently, there are two types of ATPC available. The "ramping" type increases power dB for dB with a fade greater than a certain depth. The "stepped" type increases power in a single step to maximum power when a fade exceeds a certain depth. Besides significantly aiding the frequency coordination process, ATPC also provides receiver up-fade overload protection due to the backed-off transmit power under normal signal level conditions.

4.3.2 ATPC recommendations for frequency coordination

During the coordination process, the ATPC user must clearly state that ATPC will be used. The transmit powers associated with an ATPC system included on the coordination notice are defined as follows:

Maximum Transmit Power	That transmit power that will not be exceeded at any time, used for CFM and path reliability (outage) computations, and for calculating the C/I into an ATPC system.
Coordinated Transmit Power	That transmit power selected by the ATPC system licensee as the power to be used in calculating interference levels into victim receivers.
Nominal Transmit Power	That transmit power at or below the coordinated power at which the system will operate in normal, unfaded conditions.

The Coordinated Transmit Power is restricted to a 0 to 10 dB range below the Maximum Transmit Power. The Nominal Transmit Power must be less than or equal to the Coordinated Transmit Power, with typical values ranging from 6 to 15 dB below the Maximum Transmit Power. The receive level at which the system either steps up or begins to increase (ramp up) the far-end transmit power (depending on the type of ATPC) is referred to as the ATPC Trigger Level. Because shallow fading characteristics are path dependent and unpredictable, at least a 10 dB fade must occur before the Coordinated Transmit Power is exceeded.

In order to claim a Coordinated Transmit Power less than the Maximum Transmit Power (ATPC feature is used), certain restrictions on the time that this power is exceeded must be met. Below about 12 Ghz, the expected annual time percentages should not exceed the limits shown in Figure 4-4 and provided in Table 4-2. These time percentages can be calculated by the applicable reliability calculations as shown in Section 4.2.3. First, the fade depth that causes the transmit power to exceed the Coordinated Transmit Power by a certain number of dB must be calculated. This fade depth is then substituted for the CFM in the reliability calculation. For a ramping ATPC system that uses a step increase in transmit power, a single calculation of the time that the fade depth to the ATPC trigger level is exceeded is all that is required. For an ATPC system that increases (ramps up the) power in a linear dB for dB fashion, calculations of the time that the Coordinated Transmit Power is exceeded and the time that the Maximum Transmit Power is reached are sufficient. Future ATPC systems that boost transmit power in some other way may require time percentage calculations for the entire range of transmit power in excess of the Coordinated Transmit Power.

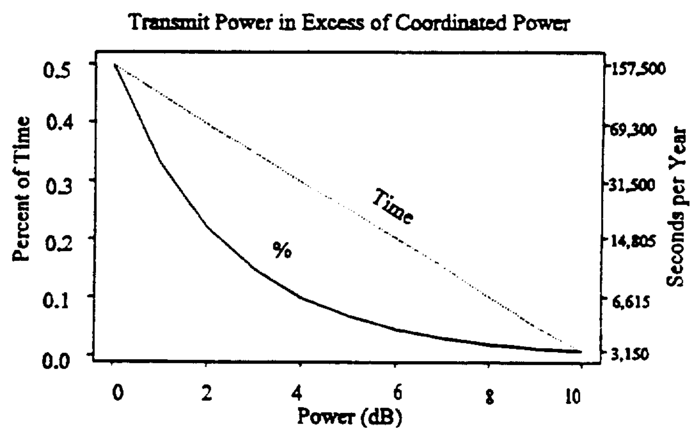

Figure 4-4 — Permitted Time Above Coordinated Transmit Power

In dB steps above the selected Coordinated Transmit Power for ramping-type ATPC systems, the permitted time percentages (and annual transmit power boost times) are shown in the following table. Only one single value (+6, +10 dB, *etc.*) need be considered in step-type ATPC systems (see examples in Section 4.3.3).